IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	
D. Wolin *et al.*	:	Group Art Unit 2187
Serial No. 10/712,451	:	Examiner: Luk, Lawrence W.
Filed: 11/12/2003	:	Date: June 26, 2006
For: APPARATUS AND METHOD	:	
FOR CHARGING AND ...	:	

AFFIDAVIT UNDER RULE 1.131

Commissioner of Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

We, Dale Wolin, Eugene Cohen and Richard G. Sevier, hereby declare that we are the inventors of the APPARATUS AND METHOD FOR CHARGING AND DISCHARGING A BATTERY disclosed and claimed in the above-identified patent application.

Enclosed herewith are copies of our notes and an invention disclosure which show that the invention was conceived by us on or before 01/18/2001.

We worked diligently on the invention from conception until the application was filed November 12, 2003. Our conception and work on the invention occurred in the United States of America.

We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Inventor: Dale Wolin

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Citizenship: United States

Dale Wolin _____ 6/26/06

Dale Wolin Date

Full Name of Inventor: Eugene Cohen

Address: Eagle, ID

Citizenship: United States

Eugene Cohen _____ 6/26/2006

Eugene Cohen Date

Full Name of Inventor: Richard G. Sevier

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Citizenship: United States

_____ _____

Richard G. Sevier Date

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Full Name of Inventor: Dale Wolin
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Dale Wolin Date

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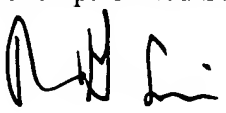
Eugene Cohen Date

Full Name of Inventor: Richard G. Sevier
Address: Boise, ID
Citizenship: United States



06-26-06

Richard G. Sevier Date

Enter PD Number

HEWLETT PACKARD

Tag Number: T0000078

INVENTION DISCLOSURE

PDNO: 10012464 ATTORNEY: AJB

MNS-801

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Red text indicates a required field.

Descriptive Title of Invention: Battery Charging and Discharging Algorithms Optimized for High Temperature Environments	
Name of Project: Cassini	
Product Name or Number: VA7100	
Submitter Location (City): Boise Idaho	
Was a description of the invention published, or are you planning to publish? If so, the date(s) and publication(s):	
No	
Was a product including the invention announced, offered for sale, sold, or is such activity proposed? If so, the date(s) and location(s):	
Yes	Please contact Gil Chacon in MSN Marketing
Was the invention disclosed to anyone outside of HP, or will such disclosure occur? If so, the date(s) and name(s):	
Yes	Molicell; Moltech
If any of the above situations will occur within 3 months, call your IP Attorney or the Legal Department now at 1-857-2542 or 650-857-2542	
Was the invention described in a lab book or other record? If so, please identify (lab book #, etc.)	
No	
Was the invention built or tested? If so, the date:	
Yes	August 2000
Was this invention made under a government contract? If so, the agency and contract number:	
No	

Description of Invention: Please describe your invention in detail using the following outline.

A. Prior solutions and their disadvantages (attach copies of any pertinent product literature, technical articles, patents, etc.).
B. Problems solved by the invention.
C. Advantages of the invention over what has been done before.
D. Description of the construction and operation of the invention.
(include appropriate schematic, block & timing diagrams, drawings, samples, graphs, flowcharts, computer listings, etc.).

Electronic Attachment

List any pertinent patents material to the invention.

List any articles or references or devices pertinent to the invention.

Identify Inventor(s): Pursuant to my (our) employment agreement, I (we) submit this disclosure on this date: 02/13/2001				
Employee No. 22622	Name: Dale Wolin	Telnet: 396-2179	Mailstop: 831	Entity & Lab Name: MNS Lab
Employee No. 524722	Name: Eugene Cohen	Telnet: 396-3918	Mailstop: 833	Entity & Lab Name: MNS Lab
Employee No. 48726	Name: Dick Sevier	Telnet: 396-3565	Mailstop: 831	Entity & Lab Name: MNS Lab

Identify Witness(es): *(It's best to identify the person(s) to whom invention was first disclosed.)*				
The invention was first explained to, and understood by, the witness(es) on this date: 02/13/2001				
Name: Barry Oldfield	Employee No.	Telnet: 396-4434	Mailstop: 831	Entity: MNS Lab
Name:	Employee No.	Telnet:	Mailstop:	Entity:

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Hardcopy Files:

Battery Charging and Discharging Algorithms Optimized for High Temperature Environments.doc

Title: Battery Charging and Discharging Algorithms Optimized for High Temperature Environments

A. **Problems solved by the invention.**

Batteries are often employed in computing hardware to provide backup power in cases of power interruption or failure of a related hardware component. Unfortunately, battery chemistries do not encourage elevated temperature use. For example, the industry standard maximum temperature for Li-Ion technology is about 45C. It is not unusual for a battery to be used in a location of a system where the surrounding temperature could be much higher than 45C due to elevated ambient temperatures combined with preheating of upstream air by other electronics and hardware. The typical solution to address the high temperature limitation of the battery would be to locate the battery in a cooler but sub-optimum location from a product density standpoint.

B. **Prior solutions and their disadvantages**

Prior solutions that do not compensate for high temperature environment are forced to make the following compromises:

Charge Oriented Issues

- Locate the battery in a cooler location that may not be optimum from a connectivity, serviceability or space efficiency standpoint.
- Optimize the location of the battery but suffer lower battery life or charge level due to elevated battery temperature.

Discharge Oriented Issues

- Allow higher levels of discharge current to take place at high temperature. This will allow the cell temperature to be higher.
- Allow higher levels of discharge current into resistor load, if used, which will elevate temperatures of surrounding circuitry causing reduced life and/or reduce performance

Either charge or discharge scenarios could lead to derating of overall system temperature. The battery could easily be the thermal "weak link" in system.

C. **Advantages of the invention over what has been done before.**

Reduced Charge Rate At High Temperature

The advantage of having battery charge rate as a function of temperature is to reduce the temperature rise induced by the charging process itself. Any reduction in the self-heating of the battery can will allow the battery to function in a correspondingly warmer environment at the system level. For example, a reduction of the charge current by 50% will reduce the power and hence self heating term by the square of the change, or 75%. **This could easily provide the**

Inventor: _____ date _____

Inventor: _____ date: _____

Witness: _____ date: _____

battery an improvement of 5C service temperature compared to a typical charge rate proposed by the industry at lower temperatures.

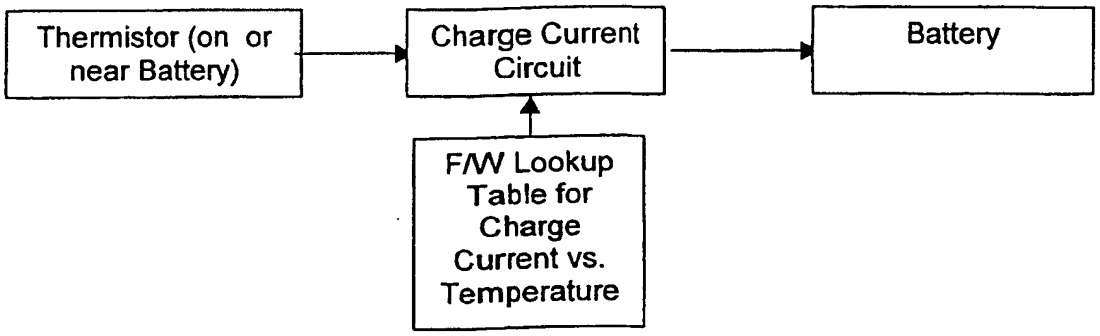
Reduced Charge Rate At High Temperature

Similar to charging, there is a self heating term in calculating cell temperature due to discharging. Often batteries are "exercised" with charge and discharge cycles to measure performance and assess capacity and life. If the discharge portion is done at a reduced rate, battery life can be increased due to reduce cell temperature.

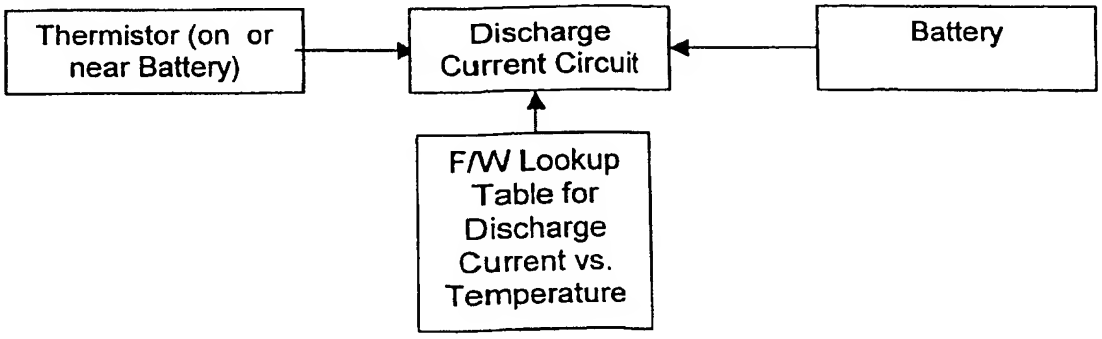
Also, the discharge current is often directed to a system of one or more resistors to provide a discharge load. These resistors may get hot and elevate the temperature of the pc board and adjacent components. Any reduction in discharge current will reduce the temperature rise of the board and adjacent components. This temperature rise reduction will increase the life and reliability of the components.

D. **Description of the construction and operation of the invention.**

Charge Circuit Block Diagram



1. Discharge Circuit



Inventor: _____ date _____

Inventor: _____ date: _____

Witness: _____ date: _____

This is a copy of e-mail showing date of genesis of concept

Dick,

Dale and I were discussing the temperature dependent charging last August. See the email below.

Eugene

-----Original Message-----
From: WOLIN,DALE (HP-Boise,ex1)
Sent: Thursday, August 03, 2000 4:34 PM
To: COHEN,EUGENE (HP-Boise,ex1)
Subject: RE: I vs. T Table

After careful analysis, I'd like to see:

T < 45C, 2.0 amps
45C < T < 55C, 1.0 amp
55C < T < 60C 0.5 amp
60C < T 0.0 amp

I'll test it out whenever you get it coded!!!

THanks,
Dale

-----Original Message-----
From: COHEN,EUGENE (HP-Boise,ex1)
Sent: Thursday, August 03, 2000 3:43 PM
To: WOLIN,DALE (HP-Boise,ex1)
Subject: I vs. T Table

Dale,

Even though you're submitting a CR/LCN for the closed-loop temperature control, could you send me the I vs. T table ASAP so I can fold it into the PIC code that I'm currently working on? The LCN will go through when it goes through but I'd like to get started on this soon.

Thanks!

Eugene

Inventor: _____ date _____

Inventor: _____ date: _____

Witness: _____ date: _____

Date/Time	Mode	Temp		Voltage(mv)	Current(+/-	AverageCu	MaxError(%	RelStateO	AbsStateC	Remaining
03/08/2001	4000	3015	28.5	11597	2091	1993	2	17	17	855
03/08/2001	4000	3016	28.6	11609	2089	2046	2	17	17	861
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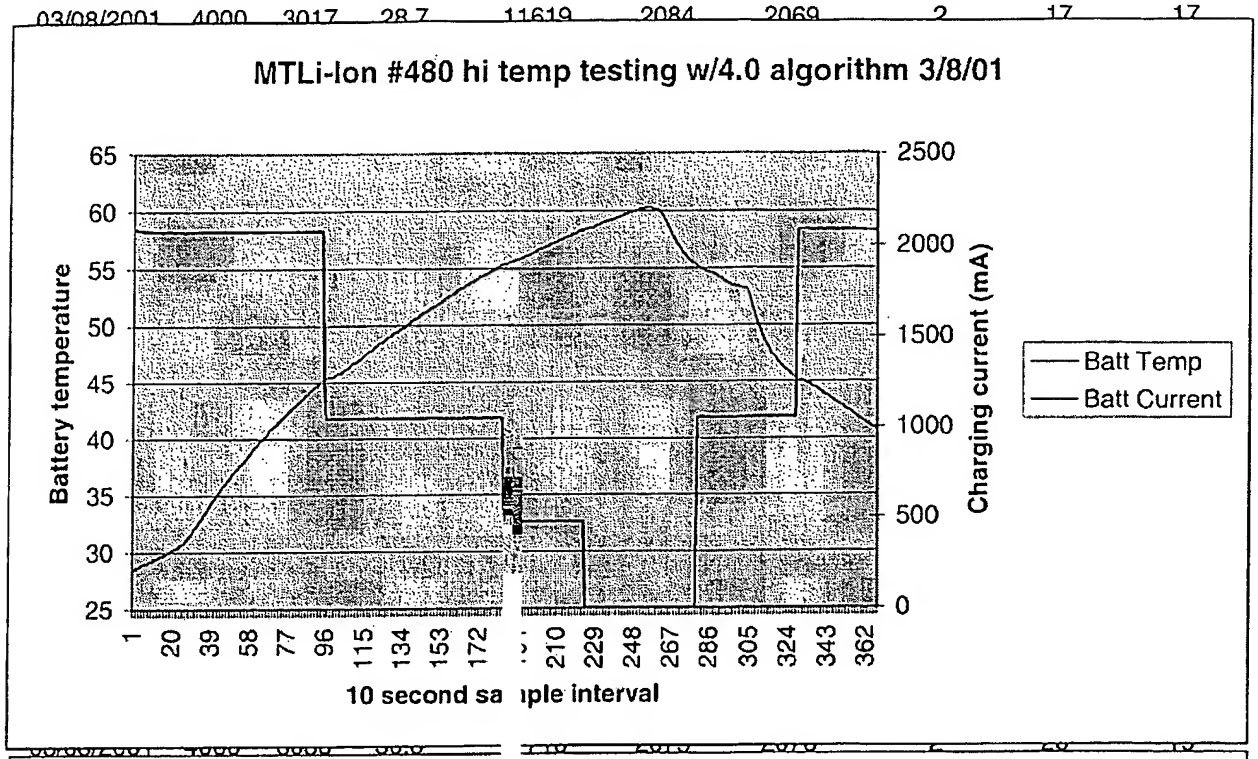

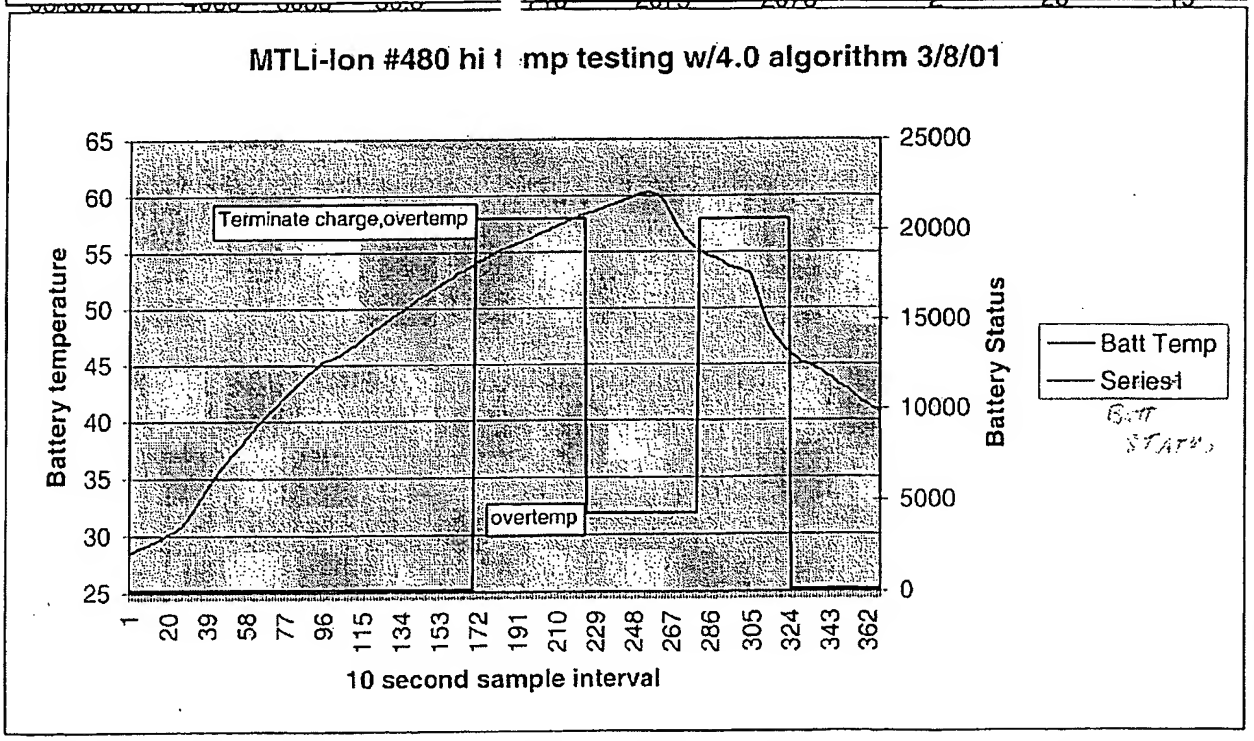

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03/08/2001	4000	3106	37.6	11718	2079	2079	2	23	23	1154
03/08/2001	4000	3108	37.8	11717	2080	2079	2	23	23	1160
03/08/2001	4000	3110	38	11718	2077	2079	2	23	23	1166
03/08/2001	4000	3112	38.2	11717	2080	2079	2	23	23	1171
03/08/2001	4000	3115	38.5	11717	2078	2079	2	23	23	1177

TITAN BATTERY CHARGER INTERFACE SPEC

Original Author:	Dale Wolin
Reviewers:	Todd Hayden, Barry Oldfield, Dan Haman, Wes Carr, Eugene Cohen, Shane Pielli, Roy Carlson, Shankar Balasubramanian, Karl Moxley, Uri Rogers, Duane Gray
Feature Set Sign-off:	Jim Jensen, Eugene Cohen, Shankar Balasubramanian, Uri Rogers, Bruce Schober, Wayne Tangen, Pete Gysling
Interface Spec Sign-off:	Jim Jensen, Eugene Cohen, Shankar Balasubramanian, Uri Rogers, Bruce Schober, Wayne Tangen, Pete Gysling, Barry Oldfield
Current Revision:	1.2

REVISION HISTORY

Revision	Revision Description	Date	Approved By:
0.1	In the beginning ...	01/10/2000	
0.2	Various changes from 1/19/2000 review	01/19/2000	
0.3	Changes from 1/27/2000 review	01/28/2000	
0.4	Clarification of overiding charging defaults, add connector part#	01/31/2000	
0.5	Remove I2C references	01/31/2000	
0.6	Change bat capacity from 4500 to 5400 mAh SDRAM holdup voltage from 3.00 to 3.15 volts	02/01/2000	
1.0	Initial release into VOB	02/02/2000	
1.1	Start of Interface Specification Enhancements	02/02/2000	
1.2	Changes from 2/10/2000 review	02/14/2000	

TITAN BATTERY CHARGER INTERFACE SPEC

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TITAN BATTERY CHARGER INTERFACE SPEC

1 Overview

The Titan Smart Battery Charger consists of a battery manager (PIC microprocessor) and charger hardware. The processor tracks the condition of the battery, charging it as needed and reporting the battery status to the system firmware via the SMBus interface. Battery discharging through a resistive load can be done via system commands to the battery manager over the SMBus interface. The SDRAM power supply receives power from the 12V system bus or from the battery when the 12V bus is unavailable. Both of these paths to the SDRAM supply are current limited to reduce inrush currents that occur during power up or switching to/from the battery. It is the responsibility of the battery manager to connect the battery to the SDRAM power supply input rail when the 12V system bus is not powered.

Features Supported:

- Complies with SMBus Smart Battery Interface
- Charger output voltage = 6V to 15V @ 2Amps for Vin = 12.0V
- Manages battery charging and discharging without the need of system firmware intervention.
- A watchdog timer monitors the PIC microprocessor to ensure the processor cannot hang.
- Reports battery status to the system firmware upon request.
- Ability to charge battery at a rate determined by the battery, up to 2.0 Amps max. This maximum can be overridden by the system firmware either down or up but never to exceed the charge rate requested by the battery.
- Ability to discharge battery at a 1.2 Amp rate.
- 10.8V to 11.1 standard Smart Battery – chemistry independent
- Battery can be completely disconnected from system via system firmware command for transport or storage.
- Charger status is visually available via an LED
- PIC processor to Battery TWS isolation from local bus during battery backup mode of operation.

1.1 Related Documents

- Smart Battery Specifications – see http://www.sbs-forum.org/specs/index.htm
- Smart Battery System Manager Specification, version 1.0 (Release B):
- Smart Battery Charger Specification, version 1.1
- Smart Battery Data Specification, version 1.1
- Smart Battery Data Accuracy Testing Guideline, version 1.0:
- I2C Specification – see http://www-us.semiconductors.philips.com/i2c/support/#general
  9398 393 40011 The I^2C-bus specification version 2.0
- SMBus Specification – see http://www.sbs-forum.org/smbus/specs/
- System Management Bus (SMBus) Specification, version 1.1
- Titan Smart Battery Charger Firmware Interface Specification
- Titan Smart Battery Charger Flash Firmware Download Protocol Specification
- Titan Controller Power Interface Specification
- Cassini Enclosure Services Interface Specification

1.2 Acyronyms and Abreviations

TWS – Two Wire Serial interface.

2 Battery Charger Operation

The Titan battery charger requires a 12V, 30W supply for proper operation. It contains a boost circuit to generate the required voltage headroom necessary to charge 10.8V NiMH or 11.1V Li-Ion battery packs. The maximum charging current available to the battery pack is 2.0 Amps via a current limiting circuit. The battery charger provides hardware support for an interface compliant to the Smart Battery Charger Specification Rev. 1.0 or later. The charger controller will also accept special commands from the system firmware to provide functionality outside SMBus specification. These commands can be used for discharging the battery for load testing if desired or to support battery fuel gauge calibration cycles.

The controller continuously monitors the status of the 12V bus. If a power fail occurs during the charging process, the controller will disconnect the battery from the charger and reconnect the battery to the SDRAM 3.3V converter.

2.1.1 Battery Charger Controller Functions

The charger will support the following functions to the system firmware:

- The charger will provide a means to discharge the battery pack .
- The system firmware has direct access to the battery pack through the TWS* (SMBus) bus.
- Interface for SMBus and Smart Battery Selector compliance.
- System firmware override of default settings. (See Titan Smart Battery Charger Firmware Interface Specification for defaults.

During shipping to customer or factory storage, the battery controller will accept a support command from the system to shut off the batteries to the SDRAM power supply before the system powers down. This will prevent the batteries from draining while the controller is not in use.

2.1.2 Battery Discharging Support

- There are load resistors on the Titan PCA to discharge the battery on command. The test is done to check the available capacity of the battery. This load is also used whenever the battery requests a re-learning cycle. See the Titan Smart Battery Charger Firmware Interface Specification for details on battery re-learning cycles.

2.1.3 Battery Hold-up Time

The battery will have enough capacity to power two 512MB DIMM modules for a minimum of 7 days in a worst case situation and when DIMM current consumption <= 39mA (typical DIMM current consumption <= 24mA). A Li-Ion battery chemistry is required for this hold up time. NiMH chemistries have approximately 80% the capacity of Li-Ion. The sizing of the battery is based on:

Samsung/Hyundai/Toshiba low power DIMM self refresh currents and verified by HP measurements

Battery mAh rating (18650F cells)	5400	Dimm DC-DC Converter Output (V)	3.15
Battery Voltage (Li-Ion)	11.1	Bus to 3.3 converter efficiency (%)	0.90
rated battery capacity (Wh)	59.94	battery end of life capacity (%)	0.88
		Gas Gauge allowance	0.90
DIMM self refresh current (mA)	39	Titan M3.3V overhead (mA)	2
Number of DIMMS	2		
DIMM HOLD UP TIME (hours)	169.5		
DIMM HOLD UP TIME (days)	7.1		

2.1.4 Backup Battery Management

In the event of a 12 VDC power failure on the Titan controller PCA, a backup battery will provide power to keep the DIMM modules alive in self-fresh mode. The battery will be a "Smart Battery" pack of either a NiMH or Li-Ion chemistry.

The backup functions are:

- Battery backup will engage automatically by the PIC microprocessor when the system detects that the main 12V bus is in an undervoltage state. Undervoltage detection is provided to the PIC by the Power Management System portion of the Titan PCA. After undervoltage detection, the SDRAM power supply must be able to sustain 3.3Volts to the SDRAM for a minimum of 100 microseconds while the PIC is connecting the battery to the SDRAM power supply input rail.
- In the absence of main 3.3V (PWR_3p3V), the SDRAM DC-DC converter will operate at a reduced output of 3.15V to reduce power consumption and increase battery life. The signal to control this reduced output will come from the PIC processor.

2.1.5 LED Status Indicator

The charger uses an LED to display various status information about the charge/discharge process.

- On, Steady state – Battery charger is online and available for charging.
- 1.0 Hz, 50% duty cycle flash rate – Battery is being disharged into the test load resistors.
- 1.0 Hz, 5% duty cycle flash rate – Battery is supplying power to SDRAM.
- LED OFF, - PIC is not powered. – Battery management unavailable.

3 Battery Interface

The battery connector on the PCA is a thru-hole soldered connector with a single row of 5 spade contacts that connect to a standard Smart Battery. The connector is non-keyed such that either a Ni-MH or Li-Ion chemistry battery can be inserted. Accidentally reversing the connection of the battery during installation is not possible due to physical orientation constraints between the battery and the mating connector on the PCA.

The connector is Amp part# 787444-1. This connector can be found at http://www.amp.com and then search on the part#.

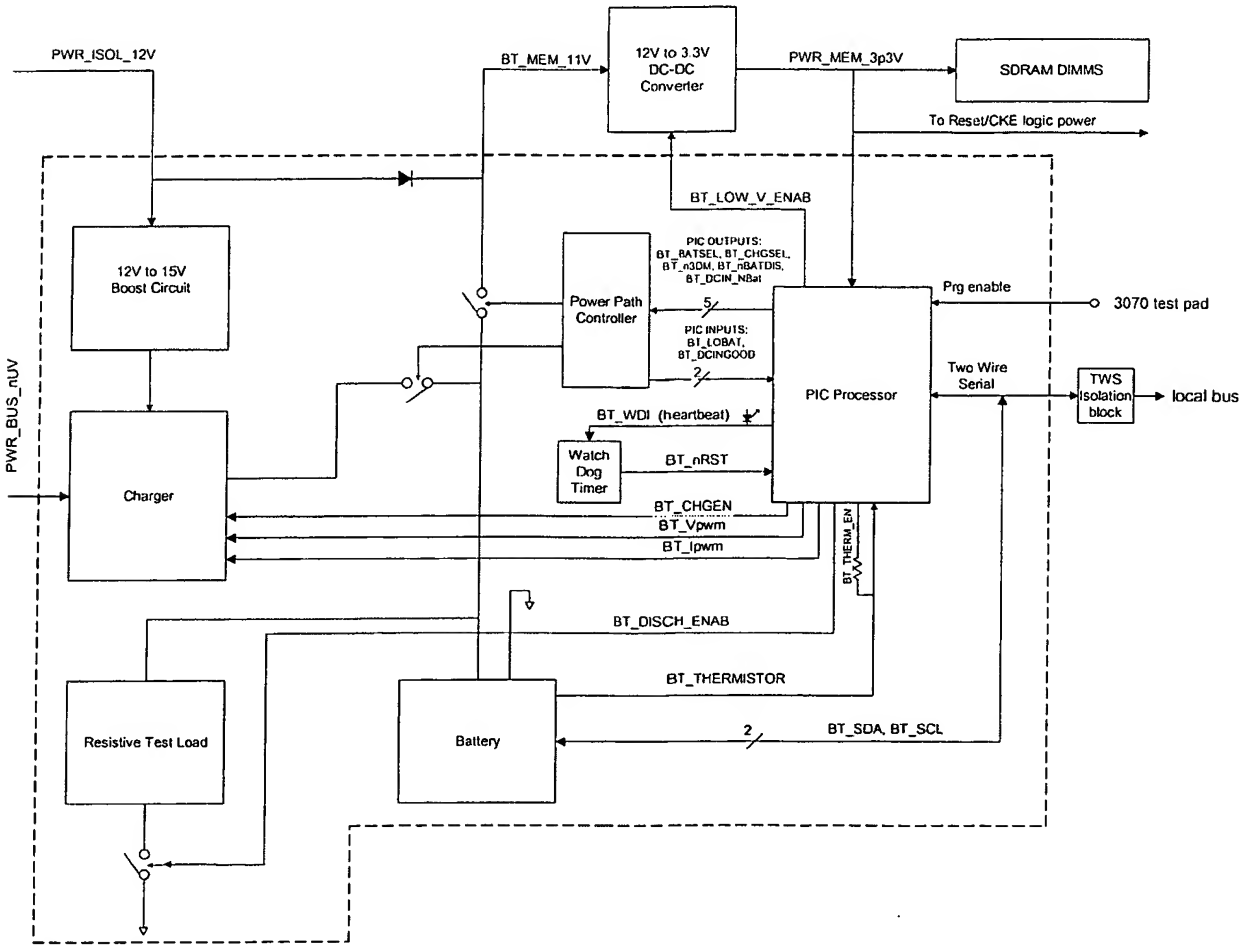
The connector is a symmetrical design and as no 'pin 1' definition other than picking one end or the other. Pin 1 will be defined then by the Smart Battery orientation on the PCA and its connector definition which is described below. Refer to *Smart Battery Data Specification, version 1.1* for details about the Smart Battery.

- Pin 1 – Negative side of battery.
- Pin 2 – Thermistor.
- Pin 3 – SMBus Data.
- Pin 4 – SMBus Clock.
- Pin 5 – Positive side of battery.

When facing the connector end of the battery with the connector slots facing down, pin 1 is located on the left side of the battery.

4 Block diagram

TITAN Battery Charger Block Diagram



5 Block-to-Block Signal definitions

Section 5 defines the internal and external I/O requirements for the charger block.
In the signal definitions that follow,

- ← Denotes that the signal is an output of the interface.
- → Denotes that the signal is an input to the interface.
- ↔ Denotes that the signal is bi-directional.

5.1 Inter-Block Connections

Section 5.1 defines signals that interface the charger block to other functional blocks on the Titan PCA.

5.1.1 Charger to Controller Power System

The Controller Power block is responsible for providing and managing power for all blocks on the Titan PCA. Refer to the *Titan Controller Power Interface Specification* for details about this block.

→	PWR_ISOL_12V	Main 12 volt bus that is used by the charger functional block to power the SDRAM DC-DC converter and the battery charger. **Requirement note**: This bus must capable of supplying at least 30 watts to the charger functional block for the battery charger.
←	BT_MEM_11V	Power for the SDRAM DC-DC converter that comes from either the PWR_ISOL_12V bus or the backup battery source. This bus will supply at least 15 watts for the SDRAM DC-DC converter in either normal or battery back-up mode of operation.
→	PWR_MEM_3p3V	3.3 volt bus for supplying power to the PIC processor. **Requirement note**: This bus must capable of supplying at least 10mA to the charger functional block.
→	PWR_ISOL_nUV	**Requirement note**: Logic low indicates that the main 12 volt system bus is in an undervoltage state and that the battery charger should be turned off immediately if charging a battery.

5.1.2 Charger to Enclosure Services

The Enclosure Services block provides environmental and communication functions for the Titan PCA. Refer to the *Cassini Enclosure Services Interface Specification* for details about this block. The following two signals connect to the isolated side of the *Enclosure Services* local bus. Refer to section 4, Block diagram.

↔	BT_SDA	Data signal for Two Wire Serial Interface.
↔	BT_SCL	Clock signal for Two Wire Serial Interface.

5.1.3 Charger to Battery Connector

Refer to section *3, Battery Interface* for details about the battery connector.

→	GND_RTN	Battery ground connection.
→	BT_THERMISTER	Battery pack internal thermister connection referenced to ground.
↔	BT_SDA	Data signal for Two Wire Serial Interface.
↔	BT_SCL	Clock signal for Two Wire Serial Interface.
→	BT_BATT_PWR	Battery power connection.

5.1.4 Charger to 3070

The 3070 board tester may be used to program a 'download kernal' into the PIC during board test. This kernal is then used by system firmware at a later process step to program the rest of the PIC with the battery charger firmware. Optionally, the PIC may be pre-programmed before being loaded onto the PCA.

→	BT_PRG_ENAB	Logic high enables the PIC to be in circuit programmed through I/O pins RB6 and RB7 when 3.3V is applied to the nMCLR pin. BT_PRG_ENAB is a no-connect signal except for factory programming and is normally pulled down by the PCA.

5.2 Intra-Block Connections

Section 5.2 defines the Microchip PIC microprocessor connections shown on the block diagram in section 4. All I/O ports of the processor are bit oriented. Refer to *Titan Smart Battery Charger Firmware Interface Specification* for details about the microprocessor operation.

Note: Regarding I/O definitions to the power path controller IC, the power path controller is a chip designed to handle up to two batteries. For Titan, only one battery is designed into the system and in the signal definitions below, **battery1** is the only battery available.

5.2.1 Microprocessor to Power Path Controller

The Power Path Controller is a device used to manage power from up to two battery sources and the main DC bus source when available. It is basically a FET switcher, directed by the PIC microprocessor as to what power source should be connected to SDRAM DC-DC converter. Important features of this device include current limiting, FET gate boost circuitry, Three Diode Mode, low bus voltage detection, and low battery voltage detection. Three Diode Mode is used by the processor during a power source switch operation for seamless switching of power. It allows either the main DC bus source or the battery to be the supplier of current to the output bus. Once the new source has been selected, the appropriate FET for that source is turned on to maximize efficiency.

←	BT_BATSEL	High connects **battery1** to the SDRAM DC-DC converter, low connects battery2.
←	BT_CHGSEL	High connects **battery1** to charger, low connects battery2 to the charger.
←	BT_n3DM	High turns off Three Diode Mode, low selects Three Diode Mode.
←	BT_nBAT_DIS	High disables battery disconnect function, low disconnects both batteries from the SDRAM DC-DC converter.
←	BT_DCIN_NBAT	High disconnects both batteries from the SDRAM DC-DC converter, low connects one of the batteries to the SDRAM DC-DC converter depending on the state of control signal **BATSEL**.
→	BT_LOBAT	High indicates that the selected battery is less than 8.5 Volts.
→	BT_DCIN_GOOD	High indicates that the SDRAM DC-DC converter should be connected to the PWR_ISOL_12V bus. Low indicates that the SDRAM DC-DC converter should be connected to a battery source.

5.2.2 Microprocessor to Watchdog Reset Timer

The watchdog reset timer is used as a power-on reset device and also as a watchdog timer in the event that the PIC code stops sending update pulses to the timer. If a watchdog timeout event occurs (which means the PIC code died for some reason), the reset device will issue a reset to the PIC.
NOTE: If a reset to the PIC occurs while the batteries are supplying power to the SDRAM, the batteries will be disconnected from SDRAM DC-DC converter and the memory contents will be lost.

←	BT_WDI	Watchdog timer to external PIC reset circuitry. The edge rate of this signal is greater than 1Hz.
→	BT_nRST	Low resets the PIC, high is normal operation.

5.2.3 Microprocessor to Charger

The charger is based on a step down voltage regulator and a current regulator. Voltage and current to the battery are limited by PWM signals generated by the processor.

←	BT_CHGEN	High enables the battery charger, low disables charger operation.
←	BT_VPWM	PWM signal to set the voltage output of the charger.
←	BT_IPWM	PWM signal to set the current limit of the charger.

5.2.4 Microprocessor to Resistive Load

The on-board resistive load consists of 18, one watt surface mount resistors connected in parallel to produce a load that nominally draws 1.2 amps when connected to 11.1 volts. The load is connected to the battery with a FET.
Requirement note: Adaquate airflow over the resistors is required for proper heat dissipation.

←	BT_DISCH_EN	High will connect the on-board resistive load to the battery. When low, the resistive load is disconnected.

5.2.5 Microprocessor to Battery support

This miscellaneous signal is used to connect the top of a resistor divider to 3.3V. The divider node is then sampled by the PIC on-chip A/D converter to determine battery type/temperature. This output is normally low to conserve battery power. Refer to *Smart Battery Data Specification, version 1.1* for details about the thermister values vs battery type/condition.

←	BT_THERM_EN	High will enable the resistor divider on the Analog thermister input.